



## Synthesised and naturally formed Akaganéite: impact on the corrosion of iron

David WATKINSON<sup>1</sup>, Kimberly ROCHE<sup>1</sup>, Nicola EMMERSON<sup>1</sup>

<sup>1</sup> *Cardiff University, United Kingdom*

Akaganéite ( $\beta$ -FeOOH) corrodes iron in contact with it due to its hygroscopicity and the mobility of its surface adsorbed chloride.<sup>1,2</sup> The high hygroscopicity of  $\beta$ -FeOOH means corrosion can occur down to 15% relative humidity.<sup>3</sup> Aqueous washing removes either some or all surface adsorbed chloride, according to the washing process and its temperature, reducing the ability of  $\beta$ -FeOOH to corrode iron.<sup>1</sup> Chloride occluded in the crystal structure of  $\beta$ -FeOOH, does not corrode iron since it is trapped in the Hollandite tunnel structure of the crystal.<sup>1,4</sup>

Research into its properties of  $\beta$ -FeOOH mostly employs synthesised samples, produced either by precipitation or solid state corrosion, as both processes mirror how it might be formed on objects. Since sufficiently pure naturally formed  $\beta$ -FeOOH is difficult to obtain in quantities suitable for use in experiments, it is often asked whether synthetically produced  $\beta$ -FeOOH reflects how the naturally formed product impacts on corrosion of archaeological objects. This study compares natural  $\beta$ -FeOOH from a 1<sup>st</sup> century AD Roman shipwreck at Saintes-Maries-de-la-Mer, with  $\beta$ -FeOOH, synthesised by acid hydrolysis of  $\text{FeCl}_3$  solution<sup>5</sup> and by a solid state method of  $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ /iron powder mixture to high humidity<sup>6</sup> (Turgoose 1983). Their crystal structure is identified, the impact of each on the corrosion rate of iron was determined quantitatively and their chloride content was measured. Corrosion rates are compared to recently published data on the corrosion rates of over 100 archaeological iron objects.<sup>7</sup>

1. Watkinson, D. and Emmerson, N., 2017. The Impact of Aqueous Washing on the Ability of  $\beta$ -FeOOH to Corrode Iron. *Environmental Science and Pollution Research*, 24, 2138-2149.

2. Watkinson D. and Lewis M.R.T., 2005. The Role of  $\beta$ FeOOH in the Corrosion of Archaeological Iron, in *Materials Issues in Art and Archaeology VII*, Vandiver P.B., Mass J.L., and Murray A. (eds.), Material Research Society Symposium Proceedings 852, Warrendale, PA, 2005, 001.6.

3. Watkinson, D. and Lewis, M., 2005. Desiccated storage of chloride contaminated archaeological iron objects. *Studies in Conservation* 50, 241-252.

4. Rémazeilles C., Refait P. 2007. On the formation of  $\beta$ -FeOOH (akaganéite) in chloride-containing environments. *Corrosion Science* 49, 844857.

5. Schwertmann, U. and Cornell, R. M. 2000. *Iron Oxides in the Laboratory: Preparation and Characterization*. 2<sup>nd</sup> Weinheim: WILEY-VCH Verlag GmbH & Co. KGaA.

6. Turgoose, S. 1982. Post Excavation Changes in Iron Antiquities. *Studies in Conservation* 27(3), pp. 97-101.

7. Watkinson, D. E., Rimmer, M. B. and Emmerson, N. J. (In press) The influence of relative humidity and intrinsic chloride on post excavation corrosion rates of archaeological wrought iron. *Studies in Conservation*.